Modular Building System

This invention relates to a modular building system and to a method of erecting a modular building.

The current practice for the construction of low rise buildings is dominated by the use of structural steel frames. The majority of buildings comprise a steel structure which is prefabricated off-site. Cladding, floors, walls and other components are then added to the framework on-site. These latter elements being built in a component sequence. The structural steel frame provides a fast construction method for the principal structure. However, all other elements are then added to the structure in a slow, time consuming manner.

Other methods are known but are less widely used. These include the use of pre-cast concrete frameworks, pre-cast flat panel construction and on-site tilt-up construction.

Tilt-up construction offers an increased productivity in the construction of the walls. However, this is at the expense of a less efficient roof structure, because the roof simply spans from wall to wall which gives no continuity between roof and wall. Therefore, bending moment forces cannot be transmitted between the two. In addition, long term stability propping of the wall panels must remain in place whilst the framing of the roof structure progresses in a traditional component by component sequence.

In recent years, since the CDM regulations have been introduced, the on-site construction required the use of

safety nets during the installation of the roof to protect the personnel working at low level from falling objects and also those working at high levels from injury due to falls.

This further reduces the economy of the traditional construction method.

It is an object of the present invention to address the above-mentioned disadvantages. It is a further object of the present invention to provide a modular building system which has the advantages of a tilt-up construction method without the drawbacks encountered in long term propping of such a construction.

According to a first aspect of the present invention a modular building system comprises at least one wall section and at least one roof section, wherein said at least one wall section and said at least one roof section include interengaging projections and openings operable to link said sections together to form a composite structure.

Preferably, the building system comprises at least two wall sections, preferably one wall section for each of two sides of said roof section. The two wall sections and one roof section may form a cell of the modular building system. Adjacent cells may be joined by means of suitable ties and construction joints.

The modular building system may comprise a plurality of cells.

End walls may be provided for the modular building system, and, with the roof section, may have interengaging projections and openings to link the end wall sections and roof section(s) together.

Preferably, the roof section is adapted to be fabricated prior to attachment to said at least one wall section, preferably as a prefabricated roof section, preferably fabricated substantially at ground level.

Preferably, the or each wall section is adapted to be fabricated prior to attachment to said roof section, and is preferably adapted to be fabricated before erection.

The wall section is preferably adapted to receive the roof section only when the wall section is in a substantially upright orientation, preferably when the wall section is in a finalised erected position.

Preferably, the or each wall section comprises at least one roof receiving opening, preferably at least two, most preferably four.

The roof receiving openings may be located on upper and lower levels. Preferably, at least two openings are provided at an upper level and at least two at a lower level.

The roof receiving openings may be located in a single member having brackets to provide upper and lower levels for the openings. The brackets may be terminal brackets.

The roof receiving openings may be located in at least one projection of the wall section, which projection may be formed by a beam or bracket secured to a main body of the wall section. Upper and lower beams may provide the upper and lower levels of roof receiving openings. Lower level opening(s) are preferably located at a different, preferably greater, spacing from the body of the wall than the upper level opening(s). Preferably, upper and lower level openings are approximately vertically aligned.

The wall section may include a support member, which may extend between upper and lower projections of the wall section. The support member may include locking means operable to retain the roof section in engagement with the or each wall section. The locking means may include a resilient locking member, preferably movable from a first position proud of the upper member to a second position at least less proud of, preferably retained within, the support member. The locking member is preferably biased towards the first position.

Preferably, the roof section includes at least one projection adapted to engage said at least one opening in the wall section.

The or each projection is preferably positioned to coincide with its corresponding opening. The or each projection is preferably attached to a boss, which may form a joint section of the roof structure, preferably at a joint of several beams of the roof structure.

The or each projection preferably extends downwards, preferably to engage with a generally horizontally

orientated opening. The or each projection may be tapered towards its lower end. The or each projection may be conical or frusto-conical, with a circular cross-section, or may be curved, or spherical.

Upper and lower projections may be provided, to correspond to upper and lower openings in the wall section. The upper and lower projections may be horizontally offset, preferably with at least one lower projection being located inward of the or each upper projection.

Preferably, the roof section is a quadrilateral with at least one, preferably two, projection at each corner thereof.

The opening in the wall section may optionally be an opening in a block section secured to the wall section, the block may be cast, and may be incorporated into the wall section as a cast element of a cast wall section. The opening in the block section may be tapered, and preferably matches the shape of the or each projection.

According to a second aspect of the present invention a joint for a modular building system comprising at least one prefabricated wall section and at least one prefabricated roof section comprises interengaging projections and openings for incorporation into corresponding wall and roof sections, the joint being adapted to allow joining of the prefabricated wall and roof sections to form a composite structure.

The features of the interengaging projections and openings referred to in the first aspect may be combined with the joint described in this aspect of the invention.

According to a third aspect of the present invention a method of forming a building comprises:

forming at least one wall section;
forming at least one roof section;

tilting-up said at least one wall section to an upright orientation;
temporarily supporting said at least one wall section;
lifting the prefabricated roof section;
and
lowering the prefabricated roof section onto the wall section;
wherein the wall section and roof section are held together by means of interengaging projections and openings thereof to thereby form a composite structure.

The method advantageously uses prefabricated wall and roof sections to form a building which is held together by the interengaging projections and openings to allow the formation of a composite structure, in which forces are readily transmitted between the roof section and one or more wall sections.

The interengaging projections and openings are preferably as described in relation to the first aspect. Also, all of the features described herein can be combined with any of the above aspects.

Specific embodiments of the present invention will now be described, by way of example, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective view of a prefabricated wall panel in an upright position ready to receive a roof structure;

Figure 2 is a partial schematic perspective view of a roof structure to be secured to the wall in Figure 1;

Figure 3 is a partial schematic perspective view of the roof structure secured to the wall panel;

Figure 4 is a partial schematic perspective view of a joint between the roof structure and the wall panel;

Figure 5 is a schematic partial side view of the roof structure secured to the wall panel;

Figure 6 is a partial schematic side view showing a restraint bar of the wall panel holding the roof structure in position;

Figure 7 is a schematic perspective view of an alternative embodiment of wall panel;

Figure 8 is a partial schematic front view of two of the alternative embodiment of wall panels joined together;

Figure 9 is a schematic perspective view of a socket section of the alternative embodiment of wall panel; and

Figure 10 is a partial schematic view from above on the line CC in Figure 8.

A modular building construction system preferably uses either concrete or steel-framed wall panels 10 to which are secured roof receiving elements 12, 14 formed by steel girders aligned lengthways close to an upper section of the concrete wall panel 10. As shown in Figures 2 and 3 a roof structure 16 has pairs of upper and lower projections 18a and 18b respectively (shown in this Figure as conical but which may optionally be of a different shape), which are received in corresponding openings in the roof receiving elements 12, 14. With the interengagement of the roof structure 16 and the concrete wall panels 10, one of which is used at each side of the roof structure 16, the building is structurally sound with the walls 10 being held in an upright configuration by the roof structure 16 and the roof structure 16 being held up by the concrete wall panels 10. Temporary propping to the wall panels can be removed at this stage.

Each building is composed of at least one cell comprising two walls 10, one at each side of the roof structure 16. Multiple cells may be used to create longer buildings, with each extra cell being placed adjacent to a preceding cell. End walls 10 are erected at ends of the building and secured in the same manner as the walls 10 described above.

A number of the details of the method used herein are common with those used in standard tilt-up construction, such as the use of preformed concrete wall panels 10 which

are erected on a concrete base and temporarily held in position by supports (not shown).

It is in the jointing system and the use of both prefabricated wall panels and prefabricated roof structures that the building system and method of erection of a building described herein have significant advantages.

The system will now be described in more detail.

The concrete wall panels 10 have a series of holes (not shown) therein to receive fixings for the roof receiving elements 12, 14 at their locations on an upper section of the wall panel 10. The roof receiving elements 12, 14, are secured parallel to each along the length of the concrete wall panel 10 with suitable fixings, such as bolts, which are placed in the holes mentioned above or alternatively shear studs may be used (cast into the wall) which are located at similar spacings.

Extending between the roof receiving elements 12, 14 are support sections 20. In this example two support sections 20 are provided for each concrete wall panel 10, although this number may be varied according to particular conditions or requirements. Each support section has a sprung restraint bar 22, a head section 26 of which is received in openings in the support section 20. A body of the restraint bar 22 is housed in a central groove 24 of the support section 20. The restraint bar 22 is biased to pivot out of the groove 24 and to project forwards towards an interior of the building to be constructed. The bias is arranged to allow the restraint bar 22 to be pushed

into the groove 24 with suitable pressure by allowing the restraint bar 22 to pivot about the head section 26.

The roof structure 16 is generally in the form of a prefabricated structure formed with steel girders 28 and a roof covering 30. The roof structure 16 differs from existing roof structures at least in view of being prefabricated and having upper and lower bosses 32a and 32b respectively, which carry the upper and lower projections 18a/b respectively. The upper and lower bosses 32a and 32b are generally arranged in pairs on each section of the roof structure 16 with each pair generally being to each end of the roof structure. Although not shown in Figures 2 and 3 the two corresponding pairs of upper and lower bosses 32a/b are included at the opposite side of the roof structure 16 shown to engage with an opposite wall panel, identical to the wall panels 10 already described.

The upper and lower bosses 32a/b are more clearly shown in Figures 5 and 6. The upper and lower bosses 32a/b form jointing sections of the roof structure 16 with the lower boss 32b being located slightly inward of the upper boss 32a, as shown in Figure 5.

As also shown in Figure 5 the lower roof receiving element 14 is approximately twice as wide as the upper roof receiving element 12 and so projects approximately twice as far from the wall panel 10. To allow for the offset between the upper and lower bosses 32a/b the openings 34a and 34b in the roof receiving element 12, 14 are also offset.

In use, two wall panels 10 are temporarily supported opposite each other at a separation equal to the width of the roof structure 16. The roof structure 16 is then lowered on to the two wall panels and the pairs of upper and lower projections, 18a,b which are located at each corner of the roof structure 16 are lowered into corresponding openings 34a and 34b. When lowered in position further support of the concrete wall panels is not required since the engagement of the upper and lower projections 18a,b with the openings 34a,b secures the structure making the roof structure 16 and the concrete wall panels 10 a composite structure.

As the roof structure 16 is lowered onto the wall panels 10 the restraint bar 22 is pushed out of the way into the groove 24. However, when the lower boss 32 passes the end of the restraint bar 22 the bias thereof forces the restraint bar to flick upwards and extend over the top of the lower boss 32b. With the restraint bar 22 in that position the roof structure 16 cannot be removed or moved upwards because of the projecting restraint bar 22. If it is required to remove the roof structure 16, then the restraint bar 22 must be held out of the way whilst the roof structure 16 is lifted.

The building structure consisting of the wall 10 and roof structure 16 provides continuity between the principal structural elements of the building in a way which has not been used before to create the load supporting structure. This method of construction creates structures which are both economic and quick to construct. A stable structure is provided built from components constructed entirely at

ground level and a structural framing arrangement is maintained.

The provision of upper and lower projections provides resistance to bending forces between the walls and roof, as does the offset of the upper and lower projections.

It is the concept of providing continuity between the walls and the roof through the jointing mechanism which is has significant advantages.

The jointing between the walls 10 and the roof structure 16 provides two principal functions. Firstly, the joint provides continuity between the roof structure and the wall structure, allowing the strength of the walls to resist bending induced by loading applied to the roof. Secondly, quick interlocking between the walls and roof structure allows the roof to be lowered onto the wall panels which then lock with the roof structure to form a stable building structure immediately upon erection.

The method of construction requires a larger crane than would normally be used for traditional methods, but since the roof structure is extremely lightweight, large areas of roof can be constructed on the ground in a very short space of time.

In view of the construction being generally ground based, the risk to health and safety are also greatly reduced. In addition, the need for netting to prevent workers on the ground from falling objects and to prevent high level workers falling to the ground can be avoided.

Figures 7 to 10 show an alternative embodiment of the composite building system mentioned above. In this embodiment cast steel socket connection blocks 40 are built into the wall 10 by means of links 42 as shown in Figure 9 which allow casting of the blocks 14 into the walls 10. The blocks are located towards the end of each wall 10 but are used with the same type of roof structure as described in relation to the first embodiment. As can be seen from Figure 8 two sections of wall 10 can be placed side by side using adjacent pairs of blocks 40. Two sections of wall 10 could then be joined together by use of upper and lower bosses 32a and 32b similar to those described in relation to the first embodiment, but having pairs of projections 18a and 18b next to each other to allow two walls to be tied together with a single section of roof structure.

Otherwise, the use of this second embodiment is the same as the previous embodiment and the roof structures used are the same. The same advantages are found with this type of construction also.

The composite action between roof and walls afforded by the joint mechanism described herein will act to reduce the overall bending moment at the mid span of the roof members, when compared to a similarly loaded member spanning the same distance between simple supports.

Other jointing mechanisms are also possible between the wall and the roof panels provided these maintain continuity to transfer bending moments from the end of the roof into the top of the wall.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extend to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.